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Ubiquitous Computing Support for Student Group Work

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Abstract

Both employers and educators see group work, a generic skill, as important and essential. However students often find group work inconvenient and face difficulties in managing time to meet face-to-face for a meeting or circulating documents to share work. The development of relatively new technologies like ubiquitous computing provides new opportunities for support for student group work. This was modelled through teaching in our Information Systems subject where students were asked to explore ubiquitous computing support for student group work. In this paper we present some useful requirements analysis and design techniques and discuss the work practices identified by the students, the requirements identified for ubiquitous support for student group work and their design solutions.

Keywords

Ubiquitous computing, student group work, work practices, requirements analysis, iterative design, prototyping

INTRODUCTION

Students at the University of Canberra are required to do considerable group work in order to learn how to use a team approach to the analysis, design and implementation of computer-based systems – a generic skill seen as essential by employers (Davies & Deshpande, 1995). Group work is complex but rewarding. However, students find that group work can be inconvenient and constrain their usual work practices with the need to balance between study and other commitments. The main difficulties involve organising and attending group meetings, and the circulation of documents between group members, particularly when part-time students are involved (Collings et al, 1997). We have attempted to address these problems by providing groupware support (mainly but not exclusively through asynchronous groupware such as Lotus Notes) and encouraging student groups to learn to work in this environment so that they can more easily work together across time and space (Collings et al, 1995, 1997, 2002). As part of this process, students have studied the differences between face-to-face and on-line meetings, evaluated different platforms such as Lotus Notes, NetMeeting, MOOs and email (Walker, 1997, 1999, Walker et al 1998) and designed support for their own group work. What was central to these designs was the need for a centralised repository with web-based access.

The development of relatively new technologies like ubiquitous computing provides new opportunities for support. Students are dissatisfied with the lack of richness in interaction (i.e. in sharing design ideas) while using media, either text based (e.g. e-mail, chat, asynchronous groupware) or voice (phone, usually one to one). They want to hold meetings anytime, anywhere to get fast feedback on tasks completed. Students often are not able to communicate with other members due to lack of resources available to track members anytime. This year (2003) we revisited the analysis and design of systems to support group work – our aim was to have students explore ubiquitous computing support for student group work.

In this paper we discuss the work practices identified by the students, the requirements identified for ubiquitous support for student group work and their design solutions.

METHOD

This study is based on work done by students in the masters level subject Issues in the Design of Human-Computer Interfaces (IDHCI). There were 20 students, working in groups of 5. The aim was to identify areas where they felt that support was needed for their group work and to propose solutions based on current or future technology. These solutions constitute a “wish list” rather than being immediately implementable.

The methodology followed by student groups was an iterative design methodology incorporating ethnographic investigations as follows:

1. Each group was asked to prepare a class presentation on a topic in ubiquitous computing, and at the same time observe how they carried out this work, recording their activities (including both formal and informal communication) through diaries and observation sheets. This generated ethnographic data. The students were encouraged to use a wide range of available technology. Some of these technologies were possibly unfamiliar to the students (e.g. an asynchronous discussion tool) and worked as 'technology probes'. (Hutchinson et al, 1993)
2. Students then developed a set of requirements by identifying areas in which there is a need for technological assistance, usually because there are 'gaps' where there are things that they would like to do but cannot, or where existing ways of doing things are awkward or difficult. A focus group was used to synthesize students' ideas about ubiquitous support and link their needs based on their findings of their current work practices.
3. They then used a subset of these requirements for designing ubiquitous computing support for their work and designed, produced and tested mock-ups of artefacts (Campbell et al, 2003) to achieve this using the Bellotti framework (Bellotti et al, 2002), contextual scenarios and role-play (Howard et al, 2002).

WORK PRACTICES IDENTIFIED

The key feature of the work practices reported by the students is that their work is fragmented in both time and space. They work in multiple locations e.g. home or work and on campus for multiple projects (subjects). They perform different tasks in different environments (i.e. work and study) within externally defined time frames. Students used two approaches to clarifying their work practices. These were selected from the literature as being relevant to the understanding of group work practices.

Locales

According to the Locales framework (Fitzpatrick, 1998), locales can be seen as the set of all the places participants work and the means of communication between them. The students identified two types of locale in their work practices:

Distributed Locale

The students worked from home and/or work. They performed their tasks through the use of computers, email, telephones, mobile phones (SMS), the Internet, an asynchronous discussion tool (WebCT, Yahoo Groups), IDHCI website, printers and online video conferencing (Yahoo Messenger). Due to the distributed nature of their tasks, sharing work or information became quite difficult and the technologies used did not provide the desired services such as access to work anytime, anywhere, simultaneous file sharing of works in progress, instant confirmation/reply of messages received, reminders for meetings, automation of workflow in notifying other group members when there are documents or ideas to be reviewed, holding meetings remotely when unable to meet face-to-face, etc. For example, for one of the groups, one member worked full-time, two others worked part-time and two others were full-time students. It was very difficult for them to arrange a time to meet face-to-face. Moreover their work was scattered over different physical places (i.e. work and home and campus). They worked on the project from their workplace and ended up with multiple versions of the same document. They had to save their work on a disk or attach it to email to distribute among other members. There was no way to get instant feedback on a piece of work as not everyone owned a mobile or had access to a computing facility at work.

On Campus Locale

The groups (especially the groups with only full-time students) had regular face-to-face meetings on campus (either in the Information Sciences and Engineering (ISE) building or the Library study rooms). These meetings were used for discussions about new ideas, collating their individual tasks and making decisions. The face-to-face locale was characterised by poor technological resources. Meetings cannot be held in labs as this is too disruptive to others and most do not have portables to bring to meetings. In most places where meetings were held there were no computers, and often not even a whiteboard. Students were unable to review or edit their work using a computer, which forced them to resort to pen and paper. Groups saw this as a waste of time and effort because of having to do the work twice.

Categorisation of Work

The activities of the group can be thought of as consisting of:

- Substantive (real) work, which is the performance of tasks directly related to the goals for the work; and
- Articulation work, which is best described as “*the work needed to get the work done*” (Kuutti et al 1996, p183). Articulation work includes project management work (e.g. negotiating and allocating tasks), group maintenance work (e.g. providing encouragement and support) and ensuring that the communication mechanisms actually work (e.g. sending an SMS to someone to ensure that they reply to an e-mail message).

The purpose of the categorisation was to identify common patterns of activity that formed an important part of group work.

Firstly, the tasks related to group work (i.e. task management, group maintenance, communication, travel etc) can be categorised by separating group work from individual work.

Secondly, group work and individual work both include substantive and articulation work.

Individual Work identified: The groups’ ethnographic data showed that they divided the project into subtasks and allocated tasks to members of the group. The nature of their assessment tasks dictated that their individual tasks could be broken down into components like researching a topic, writing up the report and preparing slides for presenting their findings to the class.

Group Work identified: Group activities included discussions, arranging meetings etc. The groups met face-to-face or by other means (i.e. online, telephone etc), often in subgroups, to discuss and compile individual work.

Substantive (real) work identified: The actual work for the project involved multiple iterations of a combination of researching, writing, and presenting findings to the class. For the second half of the semester, the groups engaged in interaction design and built physical models to test the designed artefacts.

Articulation work identified: Two major things were noticeable within their work practices in terms of articulation work:

- Coordinating and managing meetings:
 - Someone would be assigned the responsibility to take minutes to capture the decisions made at the meeting.
 - Arranging a suitable time to meet was often difficult. The decision would be basically made during face-to-face meetings, as mostly everyone would be present. Otherwise email or mobile phone (e.g. SMS) was used to arrange group meetings or subgroup meetings.
 - Members would ring up or SMS others when there was something to be reviewed so that others could respond as soon as possible.
 - The groups used SMS text messages or phone for immediate contact. Group members who did not have a mobile phone were contacted through email, which meant that there was no way to hold an instant meeting.
- Distributing documents:
 - As they worked on their project from different locations, they had to somehow share the work among themselves using email or an asynchronous discussion tool. Groups scanned or printed or attached documents to an email to distribute among the members.
 - For face-to-face meetings, they printed out the materials to be read. During the meeting, they would shuffle and scribble on the documents on the table. Later, a member would edit the document to reflect these changes.
- Other:
 - Distractions. Distractions are any form of interruption by a person, thing or event that prevents the group or individual from proceeding with an allocated task. For example, a car breaking down on the way to attend a meeting, private phone calls, noise etc.
 - Travel. Travel captures any form of travel undertaken by group members to attend meetings. For example, catching a bus to attend a meeting. Group members who were reliant on public transport needed access both to bus timetables and to information about specific services (e.g. whether a bus was early or late or had already passed a specific stop).

Work Practice Problems Encountered

Categorisation of work completed by students into individual and group components, and then identifying the articulation and substantive work, appears to be useful to define the work practices within a collaborative environment. This can be viewed as a high-level conceptualisation of students' work practices and helps identify the 'gaps' between preferred work practices and technology-dictated work practices. The following table summarises the students' own words about work categorisation to identify 'gaps' and suggested, improved technology and references both distributed and on-campus locales.

Task	Problems Encountered	Desirable or improved technology
Individual Work Related	<p>Time consuming to physically look for books. Posting in an asynchronous workspace is time consuming.</p> <p>How do you know there is an email to review? Unable to access mail due to server downtime. Attachment to emails too big, difficult to download. Delayed response or lack of confirmation of received messages.</p> <p>Lack of immediate contact.</p> <p>Inconsistency in collated work in terms of writing style and formatting. How to handle duplication in report?</p>	<p>A better searching tool and filtering mechanism.</p> <p>Send SMS text message to ask to reply. Automation of workflow to notify other members when documentation is ready to be reviewed. Automatic confirmation of received messages with intuitive technology.</p> <p>Contact members immediately through text messages or other form of alert messages.</p> <p>Combining multiple documents to a consistent style using templates to support correct form of submission. Universal language translator to help with difficulty with English</p>
Group Work Related	<p>Need to use computers during discussion to do the editing job and compiling individual work. No whiteboard available.</p> <p>Forgot to bring in the file to meeting.</p> <p>Can I use someone else's computer to retrieve my file?</p> <p>How can you hold a meeting instantly?</p> <p>How can you contact a member anytime, anywhere? Wait for at least half a day for a reply to email.</p> <p>How do you know if a member is late or not attending a meeting at all?</p> <p>How to manage the project?</p>	<p>Computing facility during meeting. Some way to share and compile the physical documents used during discussion.</p> <p>Some way to access project work done at work or home. Access to group centralized workspace through other's computing device/facility.</p> <p>Microsoft NetMeeting or other available technology to do video conferencing.</p> <p>Use of SMS or other alerting service to contact for immediate reply.</p> <p>Tracking member's location through GPS facility.</p> <p>Smart PDA or project management software to help facilitate the group's teamwork.</p>
Distractions	<p>How can I be reminded of deadlines while being distracted by other undone chores?</p> <p>How do I let others know that I am going to be late?</p>	<p>Mechanism to alert individuals of deadlines. Reminding individuals what to do next and what to take etc.</p> <p>Let other members know the reason for being late.</p>

Travel	How do I know where other members are so that I can get a lift?	Track members to see who is closest or instant messaging.
	When is the bus? Have I missed the bus?	Personalised bus status report when asked.

Table 1: Student work practice problems encountered and desirable technology

REQUIREMENTS IDENTIFIED

The listings of desirable technology support by students were perceived to be needed in the context of ubiquitous computing systems. Students, through a focus group, synthesised their findings and individual desires into a ‘wish list’ of requirements. However, students emphasised the following set of requirements for their design solutions.

Documents and sharing:

It was decided by the groups that they would need to share documents among themselves so that everyone could access their work from anywhere. There would be only one copy of their documents even though they worked on them from work or home or on campus. Otherwise they would end up with multiple versions of the same document and it could be difficult to identify the current version. In addition, their requirements stated that they should be able to use others’ technological devices if they did not have access to theirs for some reason.

Enhance face-to-face meetings:

The face-to-face locale was technologically poor and thus students needed ubiquitous support during any such meetings to do both articulation work (e.g. scanning documents such as research papers) and substantive work (e.g. editing documents by participants). This was the case both for meetings of the entire group and meetings involving smaller numbers of group members.

Enhance remote/virtual meetings:

Ability to hold a meeting remotely was an obvious requirement for the student groups. Interesting enhancement to these meetings were proposed:

- The need to flag important parts of the meeting. This was valued as students needed some mechanism to capture the design decisions made at the meeting and later write-up minutes for the meeting.
- Have private conversations while in a meeting.
- Ways to enhance their experience of video conferencing.
- Ability to reach or locate other group members while waiting for their attendance at a scheduled meeting to determine if they are late or not attending at all.

Visual modelling:

In both distributed and face-to-face locales, they wanted to convey design ideas (both two-dimensional drawings and three-dimensional representations) in a visual manner whereby other members could comment on and change the design immediately during the meeting, through a shared whiteboard or manipulation of a hologram. The ability to draw rich pictures from a narrative was seen as desirable.

Enhance communication:

Students wanted the ability to communicate with each other while they are on the move. As one of the students reflects “our articulation tasks mostly required the ability for anytime, anywhere communication”.

Managing time:

Students, in general, are constantly trying to balance their study, work and social life. To help them meet the competing demands, they preferred help in organizing activities by reminders for meetings, workflow alerts for some action, personalized bus timetables etc.

Quality management:

There were a couple of aspects to quality management. Students wanted: documentation standardisation through combining multiple documents in a consistent style using templates to support the correct form of submission; to be able to present data with extra enhancements like smell, sounds, texture; to eliminate articulation work in computer use – speak and it happens; to quote and the references are automatically inserted; to draw a rich picture from a

given scenario; a better filtering mechanism in searching for materials, etc. Students termed these as “wishful thinking”.

ITERATIVE DESIGN

Students were encouraged to develop imaginative solutions that might reflect future technologies, rather than be limited by existing technologies. They tested their own designs against their own scenarios. The Bellotti framework (Bellotti et al, 2002) was used to design some aspects of the behaviour of the interaction. For example, the framework considers: how a user knows the system is paying attention; how a system knows that a user is addressing it; how the user knows that the system is acting on their command and correctly executing the intended action. They also presented their designs for review in two class sessions and used several techniques that were considered valuable, by the class, to illustrate their designs. Students:

- Developed contextual scenarios, based on identified work practices (Campbell et al, 2003);
- Developed mockups of their designs using paper and cardboard and presented them to the class through the role-play of their scenarios (Howard et al, 2002) with the support of PowerPoint slides.
- They used the feedback generated as part of their iterative design process.

DESIGN SOLUTIONS

Ubiquitous computing is characterised as having two dimensions (Lyytinen and Yoo, 2002):

- Mobile computing, which is the ability to work from any place and at any time; and
- Pervasive computing, in which computing resources are spread through the user’s environment, often in the form of sensors and other semi-autonomous devices.

Ubiquitous computing solutions contain elements of both of these, but in some one is more important than the other.

Three features of ubiquitous computing solutions are also important (Abowd et al 2000):

- Context awareness, in which a device may need to know where it is, who is using it, and/or other information about its surroundings (e.g. temperature).
- The need for different forms of interaction (in addition to keyboard and screen), appropriate to the type of device and the context of use. The Bellotti framework (Bellotti et al, 2002) was introduced to assist students in the design and evaluation of such interfaces.
- Capture of live experience, (e.g. proceedings of a meeting) and providing flexible access to those experiences later on.

The groups designed ubiquitous artefacts to support the areas they identified as needing better technological assistance. They were based on their own work practices and each group was encouraged to emphasise different aspects of their requirements. Some of the solutions are ideas for new technology, while others are innovative ways of using existing technology. Most emphasised mobile computing. Most incorporated context awareness in some form, and most used a variety of interaction modes (e.g. speech, touch, eye gaze). For details see Alam et al, 2004.

The Roaming Office

Roaming Office is built around a central data store which can be accessed through a variety of devices. The group concentrated on two of these:

1. The Access Point, which is conceived as being a bit like a laptop computer but with added functionality, and which had the full functionality needed for the system.
2. The Cray 3000, which is a wearable device about the size of a wrist watch, with limited functionality, being designed mainly for articulation work.

The design focused on two distinct problems: manipulation of three-dimensional images, in the form of holograms (using the Access Point); and locating and contacting group members, e.g. someone who had not arrived at a meeting (using the Cray 3000). At the demonstration, the group used a wireframe shape with control points to illustrate the manipulation of the holograms, but envisaged that this might actually be done by touching the hologram itself, the finger movements indicating the required changes in shape. Different users at different locations would all have copies of the hologram which they could manipulate.

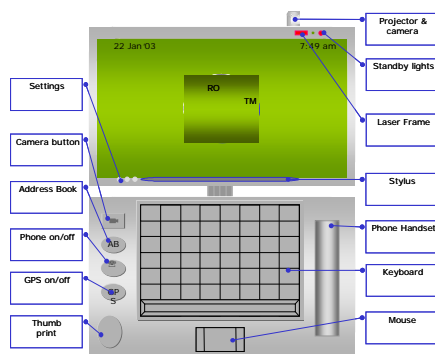


Figure 1: Access Point Features

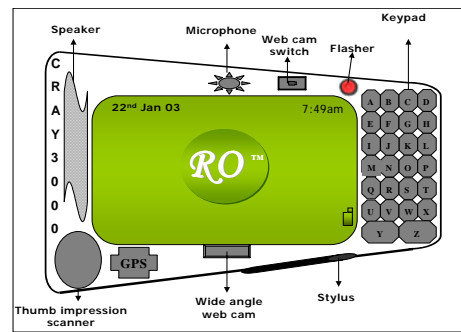


Figure 2: Cray 3000 Features

The GroupSys

GroupSys addressed the problem of being tied to a single workstation while videoconferencing. It features very thin, flexible A4-sized screens which can be attached to any surface anywhere. These contain sensors to detect both the presence of a user (who initially activates the screen and identifies themselves through a thumb print) and whether they are looking at the screen (through eye-gaze detection). There can be many of these screens in the one house. Additional sensors can be located at convenient places. Other devices, e.g. a TV set, can be connected to the system and used to display messages. Thus a user can move from room to room in their house, and perform other tasks, while still participating in the videoconferencing activity.

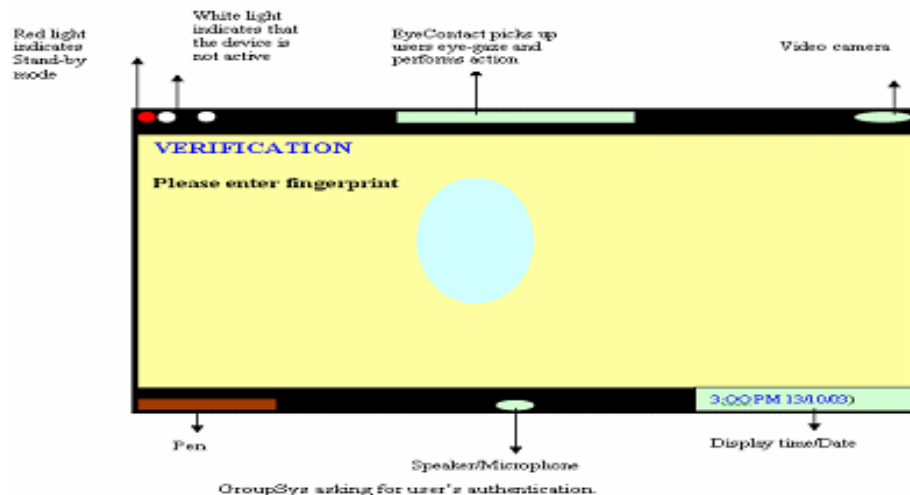


Figure 3: Features of GroupSys showing prompting for user authentication

The Mobile Team Assistant

The Mobile Team Assistant was built around a set of small portable devices like PDAs. These supported remote conferencing through video and audio streams and a facility for sending messages between participants. The key feature of this system was support for documenting what happened in meetings through the ability to “bookmark” important passages in the meeting. These bookmarks could then be used to locate the relevant video, audio and messages to compile minutes of meetings and design rationales.

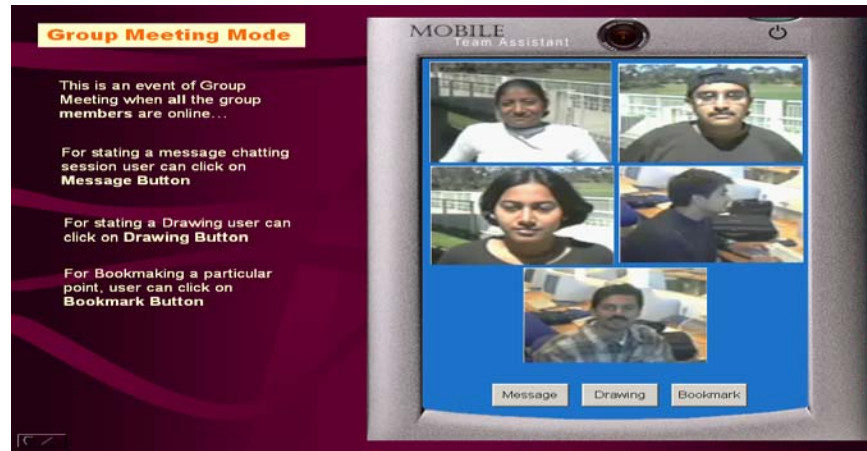


Figure 4: Group Meeting mode showing the three features: Messages, Drawing and Bookmark

The Smart Table

The fourth design solution, the Smart Table, had more pervasive elements. The focus of this solution was the enhancement of the technology-poor on-campus meeting rooms. The concept was of a Smart Room, in which the group could meet. The room had sensors, to detect who was there. The central feature of the room was a Smart Table, on which group members could lay out paper documents that they had prepared outside of meeting times. These were seen as being sections of some larger document to be compiled at the meeting. These documents could be scanned in a specified order (controlled by a touch interface) and incorporated into the larger document, which could then be edited, formatted and printed. An additional feature, attached to the Smart Table, was the Smart Book, a device that looked and acted like a book, with pages (actually very thin, double-sided displays) that could be turned over. This could be used to download content from the university library. This could be then read (as a book), or quotations extracted and automatically referenced and cited for use in the document being developed.

Sketch 1: The Smart Table

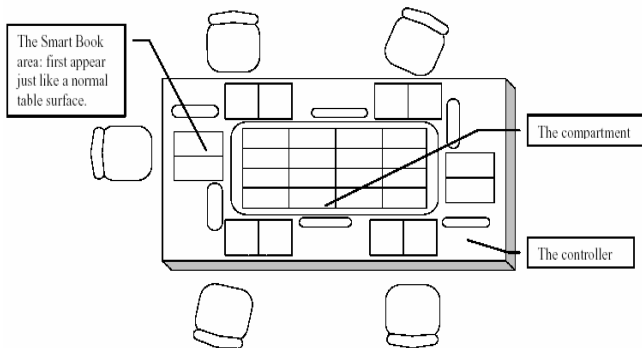


Figure 5: Features of Smart Table

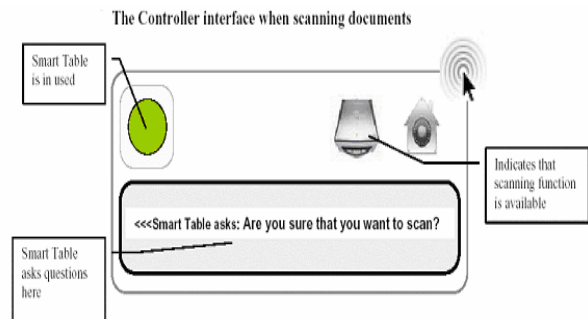


Figure 6: Controller interface for scanning documents

The Smart Table contained a mobile element, in that it was envisaged that it could be folded up and moved, and that a group member in a different location could interact with the group through another Smart Table at that location. One idea was that members at a different location might be represented by a hologram.

Evaluation

Student design work was evaluated on:

- Use of innovative techniques such as ethnographic data collection and relevant analysis frameworks.
- Design of prototypes that illustrate new ideas using a mixture of artefacts and electronic ways of showing interaction.
- Ability to convince a review audience through role-playing use of prototypes.
- Match between requirements and presented solutions.

Students usually feel some pressure to satisfy perceived requirements. In this case their interpretation of our definition of ubiquitous computing led to speech interfaces that did not present as a user requirement. However, overall, the students performed well against the criteria.

CONCLUSION

Students identified two major issues in their work practices: coordinating and managing meetings and distributing documents among team members. Students preferred a richer mode of interaction in e-meetings and wanted to share and edit design ideas visually anytime, anywhere. The high-level conceptualisation of students' work practices helped to identify the 'gaps' between their preferred work practices and technology-dictated work practices. Students identified areas that needed improvement, new or different technological support in the context of ubiquitous computing. They then designed, made, and tested cardboard mock-ups of ubiquitous computing support artefacts. Some of the solutions were ideas for new technology, while others were innovative ways of using existing technology.

Designing and understanding are iterative and interrelated activities. To design for any work practice, it is important to acquire a good knowledge of the work practice as well as analyse the context and location of activities from multiple perspectives using multiple, appropriate representations. Developing new modes of work support for student group work requires deep understanding and integration of computer technology with everyday work practices and environments. Studies such as ours help inform students and information systems developers about issues in the design of ubiquitous computing support for student group work.

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